Novel Approach to Soldier Flame Protection

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The Science Behind the Warrior: Yesterday, Today and

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Historical Use of Flame and Incendiary Weapons

- Oldest weapon known to man
- 424 B.C. - First flame projector
- 360 B.C. - Fire bombs, incendiary arrows
- 660 A.D. - “Greek Fire” used through Middle Ages
- 1500s - Introduction of gun powder
- Flame/incendiaries used in every war since, most notably WWII

ame and incendiary weapons will always have their special
on the battlefield and will pose a threat to the Soldier Syste
throughout it’s lifetime.

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Problem:

U.S. Army tankers and aviators wear aramid blend protective clothing but these materials are too expensive to issue to infantry soldiers.

Program Milestones

Establish flame protect
dismounted, mounted,
and MOUT protective clothing systems.

Demonstrate a flammability apparatus and test methodology that
simulates military flame and thermal hazards.

Demonstrate a 30 - 50% cost decrease over existing flame resistant
clothing systems while maintaining multiple threat

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Threat Generated Burn Haz

- Hydrogen Flame Weapons:
flame throwers, grenades, rockets
large caliber flame rounds.
Fuel sources are gasoline, napalm
aviation and diesel fuels.

grenades,

- Incendiary Weapons: incendiary a

artillery, shells, mortars, mines, rockets, and bombs.

Secondary Flame Burn Hazards

Ignition of battlefield combustibles by flame weapon or other threat (i.e.

ballistic,

blast, chemical, directed energy)

Accidental Burn Hazards

Fuel spills and flash fires, contact with hot surfaces, scalds (field kitchens)

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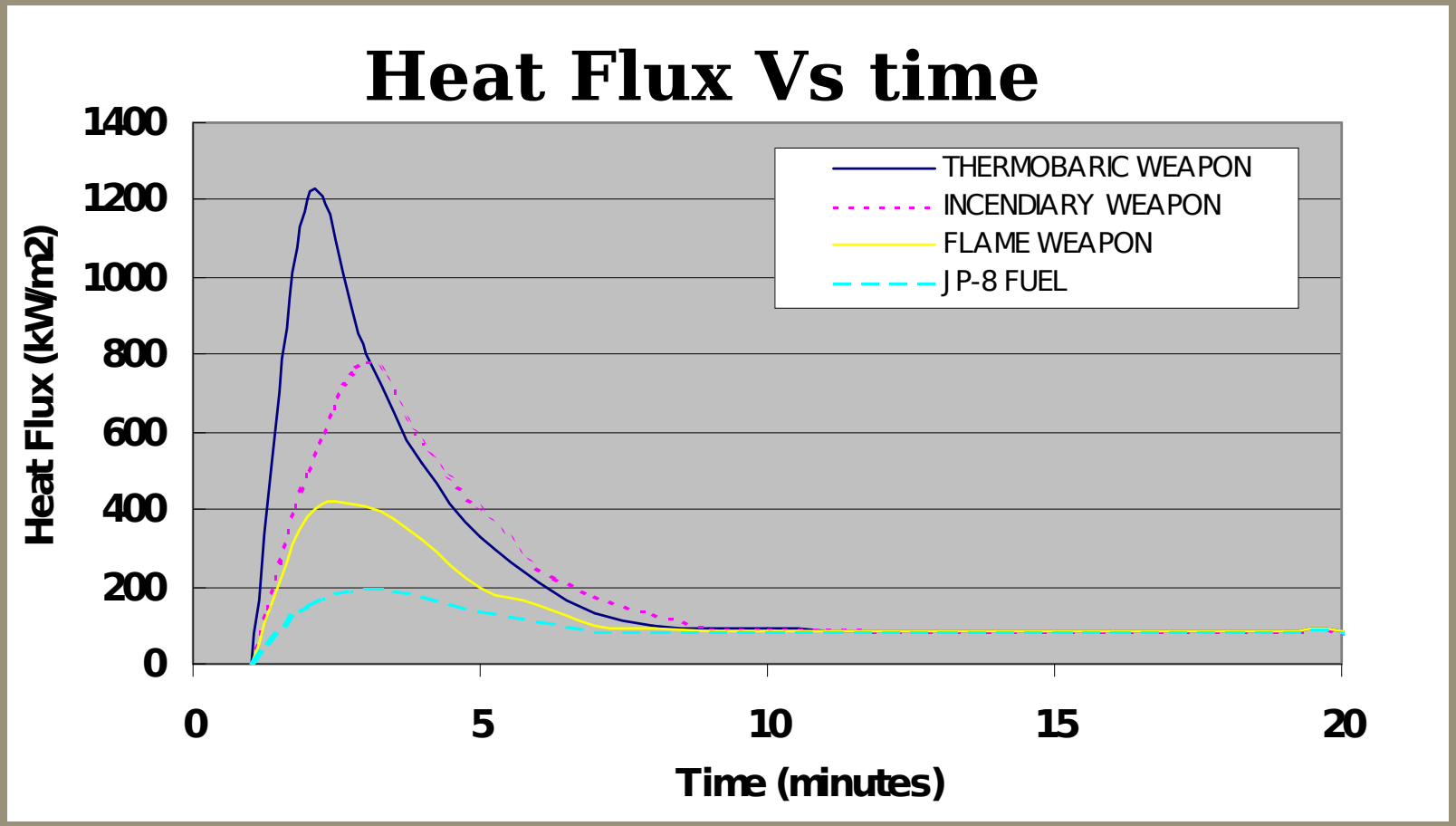

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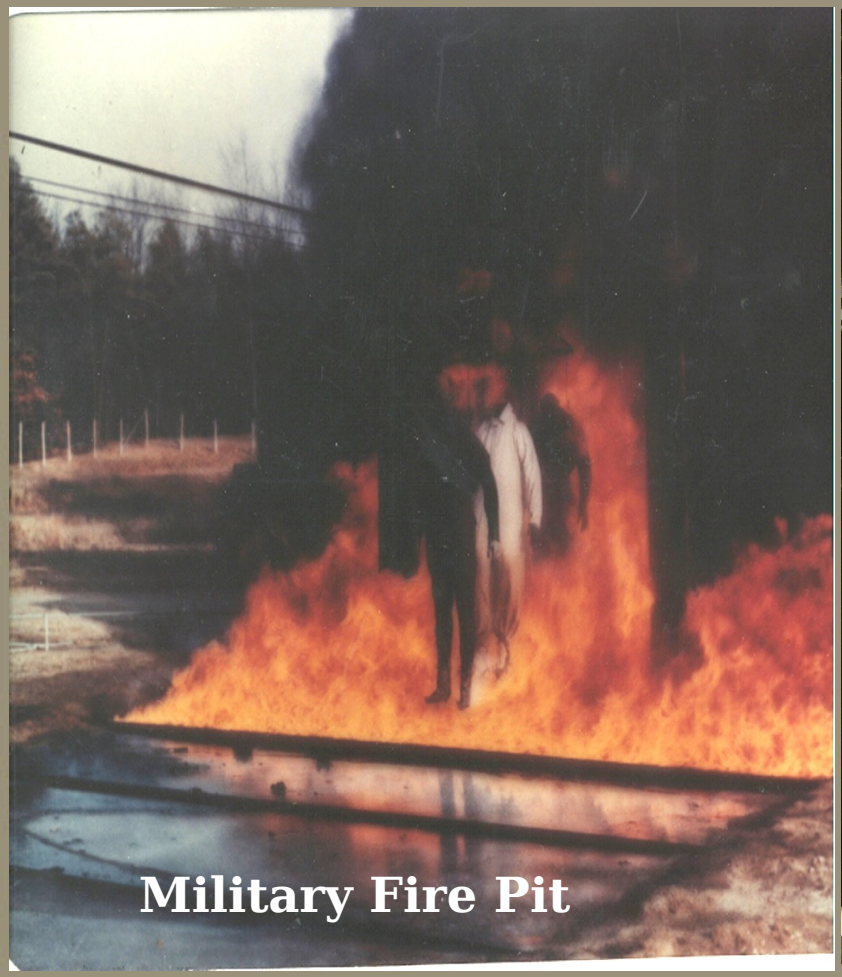

Military Fire Pit

Instrumented Manikin

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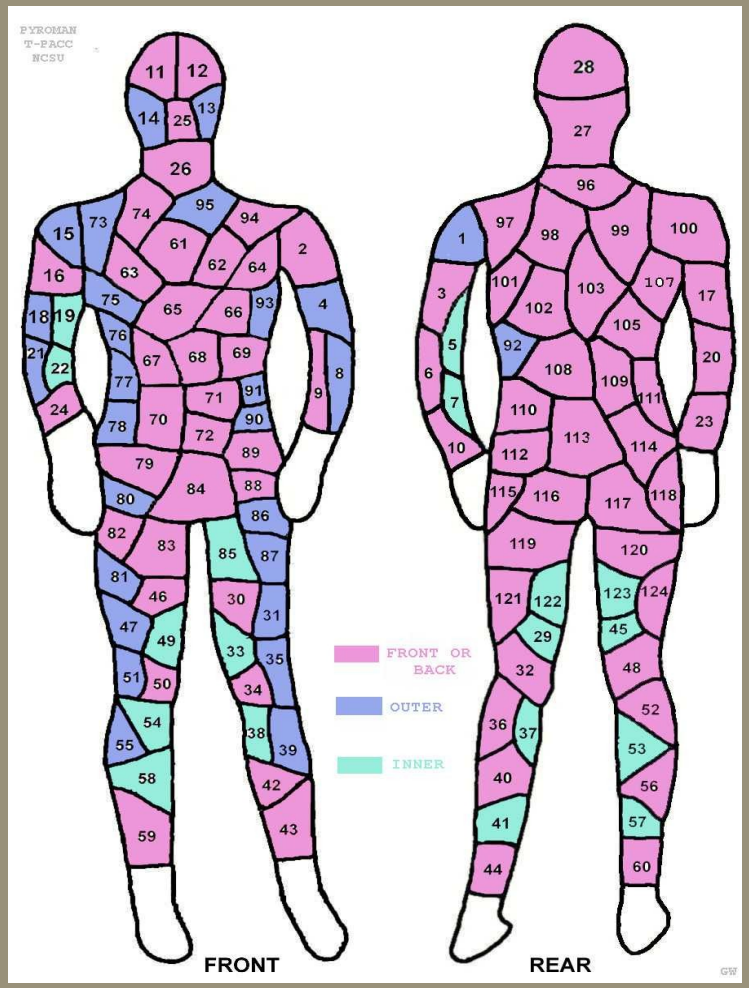

Instrumented Manikin

- ASTM 1930
- Size 40 Regular Male
- 122 Sensors
- % Body burn, 2nd, 3rd deg
- Thermal Flux - 2.0 cal/cm²
- Exposure - 2.5 to 10 sec
- Fire chamber- 8 propane t
- Military Pass/Fail Criteria –
  < 20% body burn

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Criteria for Transfer of Patients to Burn Center:

1. **Partial thickness of 20 total body surface area burn (TBSAB).**
2. **Full-thickness burns exceeding 5 percent TBSAB.**
3. **Burns involving face, feet, hands, perineum, or majo joints**

Special combat considerations:

- **Small burns involving the hand, foot or perineum.**
- **Available resources must be expended on those with greatest chance of survival.**
- **Casualties under 10 or over 60, or those with 70 per TBSAB should be allocated lesser share of resource**

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Military Clothing Systems

Flammable ***Flame Resistant Syst***

Hot Weather BDU
$54.45

Air Crew BDU
$210.35

Uri-Service Coverall
$104.85

CVC Coverall
$166.45

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Air Crew Clothing System – Summer Through

Long underwear

Air Crew BDU

Bib Coverall

Air Crew Cold Weather Clothing System

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CVC Clothing System – Summer Through W

Long Underwear

CVC Coverall

Bib Coverall

CVC Cold Weather Clothing System

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Safe Exposure Limits for Military Flame Resistant Clothing

Configuration	1	2	3	4
Layer				
One	T-shirt, Briefs *Cotton*	Long Underwear*	*Nomex* Long Underwear	*Nomex* Long Underwear
Two	Coverall *Nomex*	Coverall *Nomex*	Coverall *Nomex*	Coverall *Nomex*
Three			Jacket *Nomex*	Bib-Overalls *Nomex*
Four				Jacket *Nomex*
% Body Burn	Less than 20% At 3 seconds	Less than 20% At 4 seconds	Less than 20% At 6 seconds	Less than 20% At 10 seconds

* Cotton or Nomex

Fiber Blend		Weight, oz/sq.yd	Tearing Strength, lbs.	Breaking Strength, lbs	Camouflage Visual/NIR	Flame Resistance
MIL-C-83429 92% Nomex 5% Kevlar 3% P140	Class 5	4.7-6.0	9 x 7 (min.)	180 x 100 (min.)	Yes	Yes
	Class 6	4.3-5.0	12 x 8 (min.)	180 x 100 (min.)	No	Yes
93% Nomex 5% Kevlar 2% P140 (Spun Laced)		3.1	Does not tear	109 x 100	High potential	Yes
58% FR Cotton (sheath) 2% Mannacryl (sheath) 40% Kevlar (core)		4.5	8 x 8	107 x 61	Yes	Yes
80% FR Cotton 20% PBI		5.0	9 x 7	83 x 48	Yes	Yes
58% FR Cotton 27% Kevlar 15% Nylon		6.3	3 x 3	153 x 160	Yes	Yes
58% FR Rayon 40% Kevlar 2% Conductive Fiber		6.4	10 x 13	150 x 100	Yes*	Yes
65% Nomex 35% Rayon		6.5	9 x 6	131 x 102	Yes*	Yes
80% FR Cotton 20% PBI		6.6	11 x 6	139 x 75	Yes	Yes
Carbonized Rayon Nomex		6.9	10 x 8	198 x 125	No	Yes
100% FR Lyocell (Tencel)		7.4	6 x 7	180 x 117	Yes	Yes
88% FR Cotton 12% Nylon		7.7	6 x 7	99 x 72	Yes	Yes
88% FR Cotton 12% Nylon		11.0	5 x 9	161 x 154	Yes	Yes

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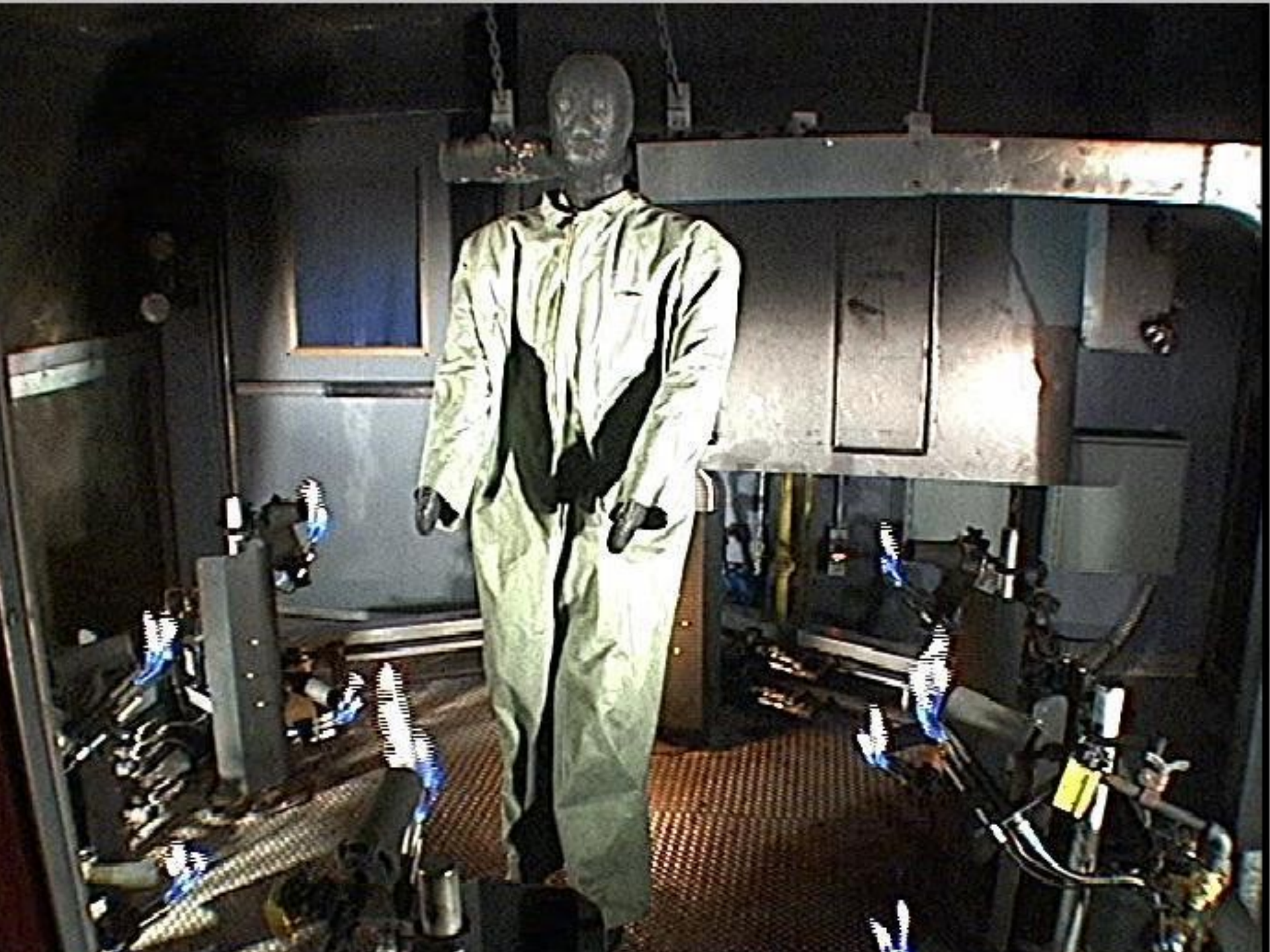
FR Materials Providing 10 – 50% Cost Savings

- Developmental combat uniform fabrics: 30 – 40%
  - FR cotton/nylon twills
  - FR rayon/aramid ripstop poplins
  - Nomex/Kevlar spun laced non-wovens
- Developmental insulation fabrics: 10 – 15% cost
  - Nomex “Polartec” knit fleece fabric
  - Adopted by SOF
- Underwear and headwear fabrics: 25 – 50 % cost
  - Basofil blend fabrics for headwear
  - Cotton waffle knit for thermal underwear
- Low cost and limited wear materials provide optio clothing system configurations.



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Summary of Thermo-Man Burn Injury Pr

Exposure Time

Ensemble	3 Seconds 2nd	3rd	Total	4 Seconds 2nd	3rd	Total	5 Seconds 2nd	3rd	Total	6 Seconds 2nd	3rd	Total
T-shirt, briefs, HWBDU	9	71	80									
	14	74	88									
T-shirt, briefs, HWBDU, Limited Wear	1	6	7	4	7	11	4	11	15	10	14	24
	0	7	7	5	7	12	3	9	12	7	13	20
	1	7	8	3	8	11	7	11	18	8	13	21

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Conclusions:

- A flux of 2 cal/cm^2 sec is representative of a survivable mi scenario if the exposure is short and protective clothing wo
- Pass/Fail criteria < 20% body burn based on military doctr
- Material selection and clothing system configuration influe
- Entire configuration does not necessarily need to be flame
- Flame resistant materials need to be outer-most or first de thermal assault and each under-layer adds insulation and p
- Military FR clothing systems provide 3 – 10 seconds of pro
- FR nonwoven overgarment recommended for infantry redu body burn from 88 to 8 percent with up to 5 seconds of ex

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Follow-up:

- Commercial FR coverall was user evaluated by US and Combat Arms (FY04). Key findings:
  - Garment must be re-sized to fit military popu
  - Re-designed to access undergarments and ac
  - Fabric is durable for nine days of wear (14 hrs
- Camouflage printed version developed.
- New garment design established.
- Fit testing completed
- Thermal manikin and final user evaluation testing